LANDSLIDE MONITORING USING GLOBAL POSITIONING SYSTEM AND INCLINOMETER TECHNIQUES

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Geomatic Engineering)

Faculty of Geoinformation and Real Estate
Universiti Teknologi Malaysia

NOVEMBER 2011

DEDICATION

To my beloved parents, Hasnah Binti Ariffin and Zainon Bin Endot (1929-1998). Thank you for all the sacrifice, the love and courage that you give me all this while. I could never be at this level if it wasn't because of you.

To my brothers and sisters. Thank you for for all the encouragement and support and love has been poured.

To my wife Roslina Binti Mohamed Touhid, the one that believes and have faith in me, thanks for the care and the unbreakable love…

To all my children Muhammad Khatimul A'fif, Muhammad Khatimul A'tif, Muhammad Khatimul A'rif, Puteri Darwisyah 'Afifah, Puteri Farisah 'Atifah,
Muhammad Khatimul A'kif and Muhammad Khatimul Ahnaf.
Make this as an impetus and inspiration for success
to achieve what is desired

A million thanks to my supervisor Prof Sr.Dr. Wan Abdul Aziz Wan Mohd Akib for all the guidance support and the great knowledge you taught me. I really appreciate it...

I also would like to give my deepest thanks and appreciation to Nor Hadija Binti Darwin and those who have given their support, ideas and comments to complete this dissertation.
Thank you...

ACKNOWLEDGEMENT

With the name of ALLAH S.W.T., the most gracious and merciful creator.

Alhamdulillah, first of all I am grateful of ALLAH for the guidance and blessing that help me a lot in completing this dissertation. Without the help I received, I never could face the obstacles and challenge while finishing this dissertation.

I would like to give my deepest thanks and appreciation to my supervisor, Prof Sr Dr Wan Abdul Aziz bin Wan Mohd Akib for helping me through my research. He had sacrifice a lot of time to guide me despite his tight and busy schedule. Not only that, he had given me a lot of brilliant idea and supportive comments in making my project successful. Without his support, help and unstoppable guidance there's no way I could complete my dissertation.

I also would like to thank all those involved in this project either directly or indirectly such as Miss Nor Hadija Binti Darwin, Mr. Azizan, Mr. Hairuddin, Mr. Aszwan, Mrs. Wati, and the entire research team for the effort and assists they gave me through this research. They contributed a lot in giving helping me during field and laboratory work. All the supportive comments and advise really help me a lot.

Last but not least, I would like to express my gratitude and appreciation to my family, all my friends and lecturers for giving me supports and help in my study. Thank you.

ABSTRACT

Landslide is one of the prominent geo-hazards that continuously affect many tropical countries including Malaysia, especially during the monsoon seasons. For the past 25 years, landslides have occurred throughout the country that caused property destruction and loss of life, especially near the hillside areas. A landslide monitoring scheme is therefore very crucial and should be carried out continuously. Various studies have been conducted to monitor landslide activities such as conventional geotechnical and geodetic techniques. Each of these techniques has its own advantages and limitations. Therefore, this study focuses on the effectiveness of the combination approach of GPS technology and inclinometer techniques for landslide monitoring. The study area is located at residential area Section 5, Wangsa Maju, Kuala Lumpur, Malaysia. In the first stage, the geotechnical data have been collected using Mackintosh probe whereby the laboratory test on disturbed soil sample has been carried out to identify the composition of the soil structures. Next, the probe test was also conducted to determine the soil layer and soil contents at the study area. The inclinometer instrument has been placed at five (5) selected monitoring points and nine (9) epochs of inclinometer measurements were made. At the same time, the GPS observations have also been carried out for nine (9) epochs separately using four (4) GPS techniques such as static, rapid static, single base Real Time Kinematic (RTK) and RTK network. This GPS network consists of four (4) control points and eleven (11) monitoring points. The GPS observations data were validated, processed and adjusted using four (4) adjustment software namely Trimble Geometry Operations (TGO) software, Topcon Tools, STARNET and GPS Constraint Program. Next, GPSAD2000 and Static Deformation programmes were used to analyse the displacement of the monitoring points. The results have shown that the GPS technique can be implemented with inclinometer technique to detect horizontal displacements up to ± 40 mm and vertical displacements less than ± 80 mm,

ABSTRAK

Tanah runtuh merupakan salah satu fenomena bahaya yang memberi kesan berterusan kepada banyak negara-negara tropika termasuk Malaysia ketika musim monsun. Semenjak 25 tahun yang lalu, tanah runtuh telah berlaku di seluruh negara menyebabkan kemusnahan harta benda dan kehilangan nyawa, terutamanya berhampiran kawasan lereng bukit. Oleh itu, pemantauan tanah runtuh sangat penting dan perlu dilaksanakan secara berterusan. Pelbagai kajian telah dijalankan untuk memantau aktiviti-aktiviti tanah runtuh seperti teknik geoteknik and geodetik konvensional. Setiap satu daripada teknik ini mempunyai kelebihan dan batasan tersendiri. Oleh itu, kajian ini memberi tumpuan kepada keberkesanan kombinasi pendekatan teknologi GPS dan teknik *inclinometer* dalam pemantauan tanah runtuh. Kawasan kajian terletak di kawasan perumahan Seksyen 5, Wangsa Maju, Kuala Lumpur, Malaysia. Di peringkat pertama, data geoteknik telah dikumpul menggunakan *Mackintosh probe* dan ujian makmal ke atas sampel tanah yang terganggu telah dijalankan untuk mengenal pasti komposisi struktur tanah. Seterusnya, ujian *probe* juga dijalankan untuk menentukan lapisan tanah dan kandungan tanah di kawasan kajian. Alat *inclinometer* telah dipasangkan di lima (5) titik pemantauan yang dipilih dan sembilan (9) epok pengukuran *inclinometer* telah dilaksanakan. Pada masa yang sama, cerapan GPS telah dijalankan dalam sembilan (9) epok secara berasingan menggunakan empat teknik GPS seperti *static*, *rapid static*, *Real Time Kinematik* (RTK) bes tunggal dan jaringan RTK. Jaringan GPS ini terdiri daripada empat (4) titik kawalan dan sebelas (11) titik pemantauan. Data cerapan GPS telah disah, diproses dan dilaraskan dengan menggunakan empat (4) perisian iaitu *Trimble Geometry Operations* (TGO), *Topcon Tools*, *Starnet* dan *GPS Constraint Program*. Seterusnya, program *GPSAD2000* dan *Static Deformation* telah digunakan untuk menganalisis anjakan titik pemantauan. Hasil kajian menunjukkan bahawa teknik GPS boleh dilaksanakan dengan teknik *inclinometer* untuk mengesan anjakan mendatar sehingga ± 40 mm dan anjakan menegak kurang daripada ± 80 mm.